Determination of Inorganic and Organic Arsenic Species in a Variety of Rice, Rice-Based Food Products, Apple and Other Juices Using IC-ICP-MS

Abstract
Recent work has shown that there are detectable levels of arsenic in rice (Oryza sativa) food products, apples and other juices. This has created significant concern to the public, the food industry and various regulatory agencies. Classic test methods are not typically used to determine arsenic species in food products. Previous work has shown that some inorganic arsenic species have greater toxicity than the total As+3 form. In this study, IC-ICP-MS method was developed to specifically validate if the inorganic arsenic species found in rice and apple and other juices were present in a variety of rice, rice-based food products, apple and other juices. This has created significant concern to the public, the food industry and various regulatory agencies. Classic test methods are not typically used to determine arsenic species in food products. Previous work has shown that some inorganic arsenic species have greater toxicity than the total As+3 form. In this study, IC-ICP-MS method was developed to specifically validate if the inorganic arsenic species found in rice and apple and other juices were present.

Introduction
Many of the current Arsenic methods are reporting the sum of the two inorganic species. A method was needed that could report the individual inorganic species due to the large difference in toxicity between the species. The IC-ICP-MS method for the precise and accurate determination of the inorganic arsenic species of Arsenic (V) and Arsenic (III) was developed to not only report the toxic properties of the food industry and regulatory agencies but also help in the assessment of the overall toxicity of the products under evaluation. The method also provides quantitation of all common organic species found in rice, rice products and juices including the arsenic organic species of dimethyl arsinate (DMA) and dimethyl monomethylarsinate (MMA) and the less common arsenic acid (AsA). The sum of inorganic and organic arsenic species was determined. Two additional reports that exist as an inorganic (AsA) and trimethylarsinate (TMA). Two different rice and rice food products and three different juice products were subjected to a single lab validation. Once the method was validated, 21 additional rice, rice-based food products, apple and other juices were obtained. Two additional precision data was obtained. The products chosen cover a wide range of food products to the public.

Sample Preparation for Liquid Products
- Liquid products were not preserved and were stored refrigerated at 0°C.
- Between 1 and 3 g of each sample was weighed into a 15 ml tared vial. Note: Two extraction blanks were included with each analysis.
- The samples were brought to a volume of 8 mL with UPW, 2 mL of 2% HNO3 and 2 mL of 2 M HCl. The next three steps were performed three times quickly to ensure adequate digestion of the sample. The samples were brought to a volume of 8 mL with UPW, 2 mL of 2% HNO3 and 2 mL of 2 M HCl.
- Between 1 and 1.2 g of each sample was weighed into a 15 mL tube. Note: Two extraction blanks were included with each analysis.
- The samples were brought to a volume of 8 mL with UPW, 2 mL of 2% HNO3 and 2 mL of 2 M HCl.
- Two additional precision data was obtained. The products chosen cover a wide range of food products to the public.

Determination
- Calibration curves were generated for all arsenic species by linear regression that was forced through the method blank and the calibration curve's concentration of the calibration standards. Precision was determined by using multiple analysts through the precision and accuracy experiments and was calculated using the method blank as the standard.

Results
- The similarity of the method was developed on a Thermo Scientific ION-ICPMS (Figure 2A). The ICP-MS method has been used in many laboratories for the determination of inorganic arsenic species. This method gives the ability to determine the level of toxicity a product has, which gives a better diagnosis of the severity of the arsenic level within a product. Publication of the method in the near future will be a significant step towards the acceptance of this method by the US Food and Drug Administration (FDA). The method was validated by using multiple analysts through the precision and accuracy experiments and was calculated using the method blank as the standard. The precision and accuracy data not presented in this paper was obtained three times quickly to ensure adequate digestion of the sample.

Conclusion
- A method for the determination of various inorganic and organic arsenic species in a variety of rice, rice-based food products, apple and other juices using IC-ICP-MS was successfully developed that produces precision and accuracy of the toxic arsenic species and inorganic arsenic species. Two different precision data was obtained. The first is the ability to provide outstanding chromatographic separation in half a time the species that normally closely together with a typical anion exchange column in less than five minutes. The second is the ability to determine the level of toxicity a product has, which gives a better diagnosis of the severity of the arsenic level within a product. Publication of the method in the near future will be a significant step towards the acceptance of this method by the US Food and Drug Administration (FDA). The method was validated by using multiple analysts through the precision and accuracy experiments and was calculated using the method blank as the standard.

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References
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